Deuteron photodissociation in ultra-peripheral relativistic heavy-ion on deuteorn collisions

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Deuteron-heavy-ion collisions are of considerable interest at heavy-ion colliders. Technically, they are much easier to produce than proton-ion collisions because the deuteron charge to mass ratio is similar to that of heavy ions, greatly simplifying the magnetic optics around the collision point.

In ultra-peripheral dA collisions, the strong electromagnetic field of the heavy-ion acts as an intense photon beam, producing very high energy γd collisions. Because the photon beam is so intense, the cross section for deuteron photodissociation is significant. The cross section for this process is [1]

$$\sigma_{\rm diss} = \int dk \frac{dN}{dk} \sigma_d(k) \qquad (1)$$

where $dN(k)/dk$ is the photon flux from the heavy ion and $\sigma_d(k)$ is the photon-deuteron breakup cross section.

The photon flux emitted by the heavy ion is obtained from the Weizsacker-Williams approach. The flux is integrated over impact parameters, b, greater than $R_{\rm min} = R_A + R_d$. The cross section $\sigma_d(k)$ is obtained from low-energy photon data. Since the photon spectrum sclaes as $1/k$, breakup is dominated by photons with energies near threshold, 2.23 MeV in the deuteron rest frame.

Figure 1 gives the photon flux weighted cross section for deuteron dissociation. For dAu collisions at RHIC, the cross section is 1.24 b, rising to 2.35 b for dPb collisions at the LHC. This is comparable to the roughly 2.5 b hadronic cross section.

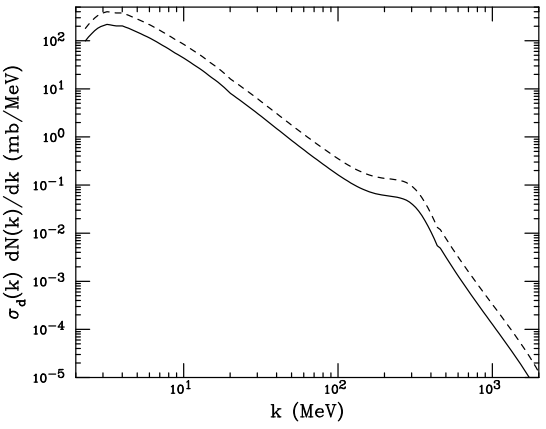

FIG. 1: Photon-flux weighted cross section for deuteron photondissociation for dAu at RHIC (solid line) and dPb at the LHC (dotted line). The photon energy is in the deuteron rest frame.

In addition to photodissociation, diffraction can also induce dissociation. In the limit of a completely black nucleus, the cross sections for diffractive deuteron dissociation are 136 mb for gold and 139 mb for lead, independent of photon energy. Since the nuclei are not completely absorptive, the actual cross sections are somewhat smaller. Because the diffractive component is small compared to photodissociation, we do not correct for the partial transparency. We find total dissociation cross sections of 1.38 b for dAu at RHIC, and 2.49 b for dPb at the LHC.

The photodissociation cross section scales with the photon flux. As long as the impact parameter b satisfies the inequality $kb < \hbar c\gamma(2\gamma^2 - 1)$, the cross section scales as $1/b^2$. For near-miss collisions, with $b = 10$ fm, the probability of dissociation in dAu collisions at RHIC is about 1.8%.

REFERENCES

[1] S. Klein and R. Vogt, Phys. Rev. C**68**, 017902 (2003).